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Technique of Grass Seed Production at the Welsh Plant Breeding Station

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HERBAGE PUBLICATION SERIES

BULLETIN 22

TECHNIQUE OF GRASS SEED PRODUCTION AT THE WELSH PLANT BREEDING STATION

By

GWILYM EVANS

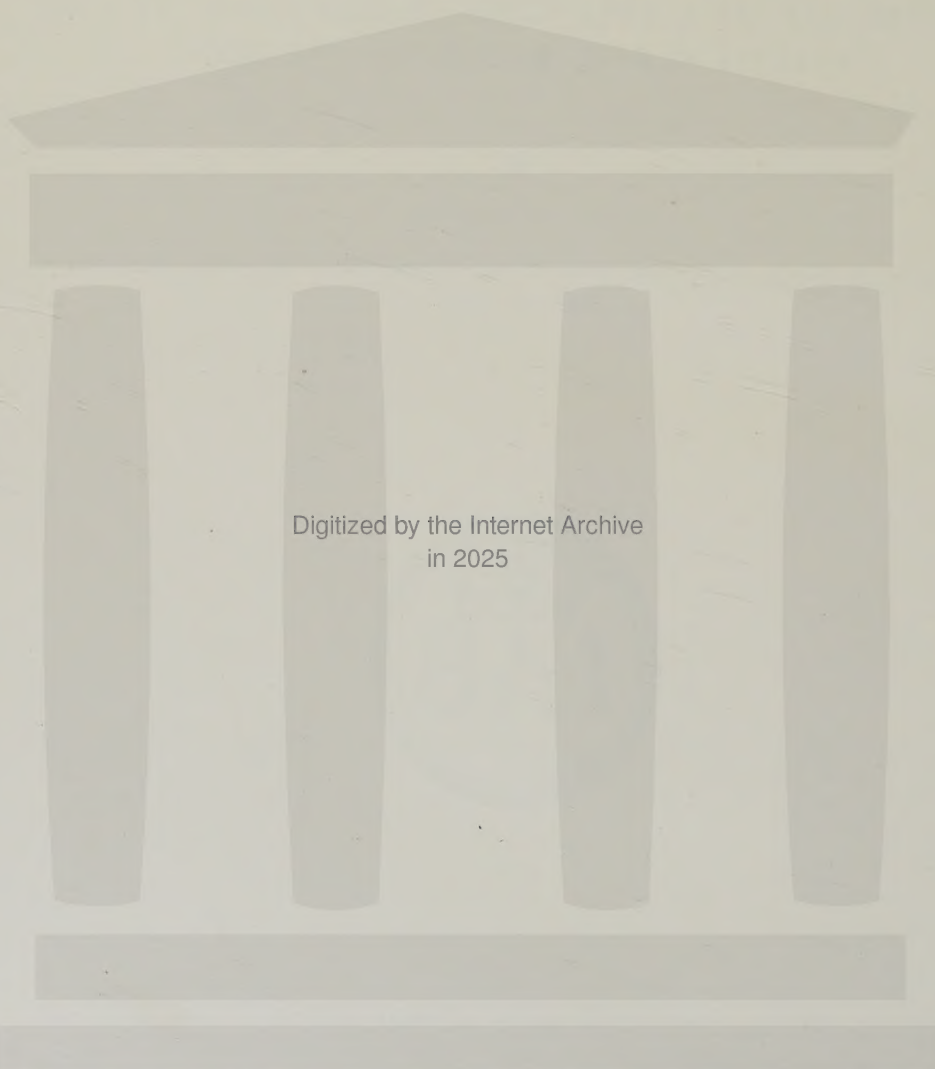
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Aberystwyth



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1.—INTRODUCTION.

The species and strains of grasses bred and grown for seed at the Welsh Plant Breeding Station are perennial or at least biennial, and with very few exceptions they are normally cross fertile. These two characteristics impose certain limitations on the technique of multiplication by means of seed, but also provide certain advantages which are absent in the case of cereals.

Seminal reproduction in herbage plants is a more involved process than seed production of cereals; in Western Europe at least there had been a long-standing tradition of growing cereal crops for their grain before any tradition of systematically saving herbage plant seeds became established. Seed growers of grass strains are far behind the cereal growers; the disparity is made still greater by the relative uniformity and simplicity of technique as applied to cereals compared with the variability of techniques which seem to be indicated for herbage plants, due to the great differences in habit of growth and longevity.

The tendency in recent years to breed herbage plants not so much for their productivity in the early years as for their quality, hardness, and longevity reacts inevitably on the technique of seed production. Methods which have produced satisfactory results in reproducing the older varieties are often found to be less satisfactory for the newer types. For example, the propensity of pasture strains for producing a relatively large amount of green foliage at harvest time calls for modification in several aspects of the ordinary practices of seed growing. In general terms, it may be stated that the older varieties of grasses and clovers are much easier to handle than many of the newer ones. They produce, on the whole, more seed than the latest strains, and the seed can be grown with fewer difficulties.

In evaluating a possible new strain of grass it is obvious that, if an innate capacity for producing a reasonable amount of seed is absent, the strain will have a very limited application on account of the high cost of the seed. On the other hand, relative weakness in seed production does not preclude the general use of a strain if pasture makers are convinced that the higher cost of the seed is more than covered by the greater value of the pasture compared with that made from ordinary seeds. There is no reason to suppose, however, that all improved strains are weaker in seed-producing capacity than older strains. Indeed, it has been shown that new leafy hay strains of perennial ryegrass, cocksfoot and timothy can produce as much seed as the older, stemmy and less persistent strains.

The seed grower must be prepared, however, for rather lower yields per acre from certain of the improved strains, in particular from extreme *pasture* strains of grasses. Such strains produce a profusion of tillers, and it is the task of the seed grower to employ such methods as will induce the maximum number of tillers to develop inflorescences. Although pasture strains may not produce more than three-quarters or two-thirds the yield of ordinary commercial strains in any one year, they are able, by virtue of their persistency, to remain in productivity longer than ordinary strains. The comparatively low seed yields obtained in wild white clover have not prevented an increasing number of growers from cultivating this variety for seed, for the continued and effective demand has ensured a price substantially above that ruling for ordinary white clover seed. Similar considerations are likely to influence seed growers in adopting superior strains of grasses, the merits of which are being appreciated by British farmers to such an extent that the demand for the seeds of pasture strains exceeds the supply, and growers can be cheered by the knowledge that even the extreme pasture types of perennial ryegrass, cocksfoot and timothy can yield well over 500 lb. of graded seed per acre under favourable conditions.

2.—ENVIRONMENT OF THE STATION.

The Station is on the west coast of Wales; the average annual rainfall is a little over 40 inches, one quarter of which falls in May, June and July.

The County of Cardigan, in which Aberystwyth is situated, is characterized for the most part by thin stony soils; 88 per cent of the total area is in grass, the greater proportion of which at lower elevations is dominated by *Agrostis* spp. The hill areas are almost entirely free from ryegrass, cocksfoot and timothy spp. The immediate vicinity of the Station is thus not considered to be ideally suited for large scale seed production, on account of the relative poverty of the soil and the comparatively high rainfall.

The following species are being bred at the Station, and one or more strains of each are in one stage or another of multiplication.

<i>Lolium perenne</i>	Perennial ryegrass.
<i>Lolium italicum</i>	Italian ryegrass.
<i>Dactylis glomerata</i>	Cocksfoot.
<i>Phleum pratense</i>	Timothy.
<i>Festuca pratensis</i>	Meadow fescue.
<i>Alopecurus pratensis</i>	Meadow foxtail.
<i>Festuca rubra</i>	Red fescue.
<i>Festuca ovina</i>	Sheep's fescue.
<i>Festuca arundinacea</i>	Tall fescue.
<i>Poa pratensis</i>	Smooth stalked meadow grass.
<i>Holcus lanatus</i>	Yorkshire fog.
<i>Anthoxanthum odoratum</i>	Sweet vernal.
<i>Phalaris arundinacea</i>	Reed canary grass.
<i>Phalaris tuberosa</i>	Tuberous canary grass.

3.—INITIAL STAGES OF MULTIPLICATION.

Seed multiplication of new grass strains is achieved in three stages, the first from a limited number of finally selected plants, the second on a limited field scale, and the third in terms of several fields for each strain.

Most of the first stage multiplication is carried out at the Station, or within a few miles thereof. The cultivation and management of all these initial seed islands are directly under the control of the staff of the Station.

The second and third stages of multiplication are made by placing contracts with growers, the great majority of whom are on the east side of the Welsh watershed. Favourable districts with low rainfall and fertile soil are chosen in the accessible counties of Montgomery, Brecon, Shropshire, Herefordshire and Gloucestershire.

The growers are paid a certain fixed sum per acre per annum, generally for three years, including the seeding year and two harvest years (except for broadcast areas under cereal, when no payment is made for the seeding year). For this payment the grower undertakes to cultivate, weed and rogue crops, harvest the seed, and store it for threshing. The Station supplies and sows the stock seed, supplies fertilizers, does the threshing, and hands over the threshed straw to the grower. The Station holds an option for further seed crops after the second.

All growers in the counties mentioned have had no previous experience of growing grasses for seed, and the technique adopted by them is that recommended by the Station.

FIRST STAGE.

Isolation.

One of the first considerations in seed production of cross-fertile species is good isolation; the pedigree strains must not be contaminated by pollen of inferior strains or strains different in type. This aspect needs particular attention in the first stage of multiplication, when the whole strain consists only of comparatively few plants. A certain quantity of extraneous pollen can have a much more damaging effect on the strain at this stage than later when the strain covers several acres.

The chief method adopted at the Station for the initial multiplication of most of the gramineous species is by means of glasshouses, 30 × 10 ft. and 20 × 10 ft. (see Fig. 1). Selected plants which are to form the basis of a new strain are dug in the autumn from the breeding grounds and split into four or more clonal units. These clones are planted in good loam soil in the glasshouses, and spaced in rows one foot apart with a foot between each plant. To facilitate subsequent attention, a path two feet wide is left along the centre of the house, covered by a latticed gangway of timber. From about 100 to 200 plants are thus introduced into the greenhouse in the autumn and produce a seed crop in the following year. (See Fig. 2.)

Until the spring the plants require little attention other than watering, no fertilizer being applied at any period unless the loam used is abnormally low in potash and phosphates. Nitrogen is not usually found to be necessary as the vegetative growth of most grasses is sufficiently vigorous under glass.

Measures are taken from time to time to control insect and fungus pests such as aphids and *Erysiphe*. Movement of pollen within the house is effected by fixing a series of canes between the plants before the inflorescences emerge, and connecting the canes lengthwise and crosswise by means of binder twine, the ends of which are drawn through a hole at the end of the house, each side of the door. When the pollen is liberated these strings are subjected to a number of vigorous pulls which shake the whole crop quite effectively. Care is taken to close the ventilating shutters and all

windows, and to lock the door before the crop is in a condition to flower, in order to keep the house as pollen proof as possible until flowering is definitely completed. During hot summers a coating of a greenish wash on the outside of the glass helps to prevent the sun from causing premature ripening of the seed.

Glasshouses have not been exclusively used for initial multiplications. Satisfactory isolation of certain species is obtainable on the Station's farm, as this is a simple matter in the case of those species which are represented only in very small quantities in the neighbourhood. Among these species are included *Alopecurus pratensis*, *Phalaris* spp., *Festuca pratensis* and *F. arundinacea*, and diploid timothy.

It has been found that perennial ryegrass (*Lolium perenne*) does not produce seed as successfully as cocksfoot (*Dactylis*) and timothy (*Phleum*) when planted in a glasshouse. Satisfactory seed yields are, however, obtained by growing the plants in flower pots in the open, and bringing them into a glasshouse for isolation before they flower.

An alternative to the glasshouse isolation for ryegrass is to grow the original plants in the open where little or no ryegrass occurs in the neighbourhood of the seed island, or where it is grazed hard. Isolated localities in the *Agrostis-Festuca* areas of Plynlimon with perfect isolation from ryegrass fields have been used successfully at 900 ft. elevation for the growing of single plants of a new ryegrass strain for seed. Such areas can be found on virgin land which has grown potatoes for two or three years, and which requires only an application of lime and a complete fertilizer to produce a reasonable amount of seed. Lime has a very marked effect on the seed production of perennial ryegrass when grown on virgin land in the Welsh hills, and the indications are that lime deficiency anywhere has to be made good before sustained seed crops of this species can be obtained. Although the conditions for producing a good seed crop are admittedly far more favourable at low elevations than in districts of higher rainfall and at higher elevation, it is claimed in favour of the *Agrostis-Festuca* hills that they have greater possibilities of good isolation. Space is not so important a consideration for establishing a seed-production island at these higher elevations as it is in glasshouses, and for this reason each clonal part of an original plant can be given ample room for its maximum development. Although no more than a quarter to a half of the seed yield on lowlands can be expected from hill islands, the disparity in seed yields from the original number of selected plants can be narrowed by dividing them into smaller units and giving such units the maximum space for development.

Grasses are less subject to certain insect pests, such as midges, at higher elevations, but on the other hand ergot and saprophytic fungi may be more prevalent where the harvest is late and the atmosphere more humid.

Harvesting.

For glasshouse crops only sufficient length of straw is cut at harvest for convenience in handling and threshing the sheaves. The harvested crop is conditioned in small sheaves on wooden trays (4 × 4 ft.) made from single sheets of three-ply wood, with 1 in. timber at the sides. Normally a week is adequate for drying the crop thoroughly after harvesting.

Crops from small seed production islands harvested in the open may be finally conditioned in glasshouses, or threshed from the field before they are thoroughly dry and later conditioned in wooden trays under glass. The drying trays (4 × 4 ft.) have stout supports 12 in. long at each of the four corners; when these trays are piled on one another to economize space, there is room between each tray to turn the seed. Care is exercised to turn both sheaves and seeds drying under glass once or twice daily, and to provide as much ventilation as possible.

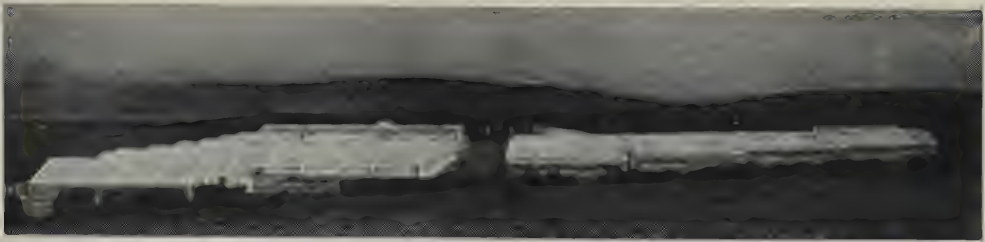


FIG. 1. General view of the glasshouses, Welsh Plant Breeding Station, Aberystwyth.



FIG. 2. Isolation for seed production of a bred strain of cocksfoot in a small glasshouse (first stage multiplication).

To face p. 8

A seed crop may also be conditioned on the field in the form of small sheaves attached to chestnut poles 8 ft. long by 3 in. in diameter, driven into the ground. The sheaves are held by galvanized wires driven through the poles at intervals (see Fig. 3). Canvas sheets are ultimately wound and tied around the sheaves and the pole before the latter is dug up. The poles bearing the sheaves are then brought under cover and stored for threshing.

Threshing.

For threshing crops from the smaller seed production islands a simple thresher with a plain (12 in.) drum driven by an oil engine is used. This machine is so constructed that every part can be readily and thoroughly cleaned between each lot threshed. The larger capacity threshers for handling the larger stocks are also constructed in a manner to facilitate access for cleaning purposes.

Small lots of such crops as sweet vernal (*Anthoxanthum odoratum*) are best threshed out by shaking the sheaves and finally beating them with a short staff. Long-strawed crops, such as cocksfoot, are dried on the field in stooks of four sheaves; these stooks are tied at the top. Much good seed is saved by shaking the stooks on to canvas sheets once or twice before they are brought indoors.

In addition to these cleaning precautions, it is customary to alternate the species passing through the threshers; instead of threshing three strains of cocksfoot in succession, a strain of cocksfoot is followed by a strain of timothy before another strain of cocksfoot is threshed.

Cleaning.

The crops from all the first multiplication grass islands, including glasshouse crops, are cleaned by means of hand sieves worked on large shallow wooden trays with three-ply bottoms. Light seeds are eliminated by a couple of very efficient metal hand blowers. As the aim is to secure as clean growing crops as possible, the cleaning resolves itself into the removal of light seed and inert matter.

From 20 to 50 per cent of the seed of timothy strains bred at the Station, as it comes through the thresher, may be covered by the glumes. This glume problem in relation to small lots is solved by passing the seed ex thresher through a small power-driven hulling machine, the main features of which are a cylinder of woven wire (in two halves) and five cane brushes revolving and coming in contact with the wire mesh. This machine is easily dismantled for cleaning after each hulling of the various pedigree strains. As a further precaution against contamination, a strain of red clover is hulled between each strain of timothy. The process of dehulling is less difficult when the seed has been derived from crops which have received a shower or two of rain when in the stook.

Recourse is occasionally made to the hulling machine for the purpose of separating viable seeds from spikelets of cocksfoot and ryegrass; a proportion of the spikelets are apt to pass through the thresher without disintegrating into their constituent units, should the ripening of the crop be somewhat uneven. Pasture strains are more subject to this than other strains, hence the need for delaying the harvesting until the crops are thoroughly ripe. The hairiness of foxtail seed and the webbing on meadow grass seeds are substantially reduced by means of the hulling machine. Yorkshire fog seed can also be removed from ryegrass, cocksfoot and fescue seeds after passing them through the huller.

SECOND STAGE.

Fewer strains are multiplied in this stage than in the first. The seed from the first stage is partly used for trial purposes. Such trials determine which of the

strains tested are worthy of being propagated to a further stage, and thus a number of strains are eliminated after the first propagation.

The glasshouses yield on the average sufficient seed to sow from 0.5 to 1 acre of land in drills 2 feet apart for seed, after allowing sufficient quantity for small field trials (see Fig. 4).

Seed islands grown in the open may yield sufficient seed to sow from 4 to 5 acres of land; thus a one-twentieth acre island of pasture cocksfoot or a pasture ryegrass strain may yield, under lowland conditions, 20 lb. of seed, or if the isolation is in the uplands, 4 to 5 lb. of seed are produced—sufficient for seeding about an acre of land (see Fig. 5).

The general technique of growing the seed is similar for the second and third multiplications, and to avoid repetition it is proposed to deal in detail with the various phases in the next section. Certain aspects, however, of the second multiplication stage require greater circumspection than in the third stage, on account of the relatively small size of the island involved in the second stage and the fact that the new strain will be multiplied at one centre only, and by one seed grower only. These aspects include the more careful choice of land, isolation, and growers. The selecting of suitable growers at this stage is important, as fewer farmers will give the requisite attention to a small island in a corner of a field than will attend to a whole field laid down for seed. The smaller the island that can be sown, obviously the greater is the need for adequate isolation.

At this stage the most economical method of propagation is less important than that which ensures the certainty of a seed crop and maximum yield from a given quantity of seed. Thus, broadcast sowings under cereals of ryegrass (*Lolium*) strains and under certain circumstances red fescue (*Festuca rubra*) strains would produce the most economical results, but such sowings would involve about four times the quantity of seed required for drills two feet apart. With small quantities of stock seed it is in general found to be advisable to sow the seed in drills of standard width without a cover crop.

The optimum quantity of seed to sow per acre is an involved question; it must vary not only with species and strain, but also with the conditions under which a particular strain is grown for seed. A thick seeding of first generation seed not only makes the area of the seed island smaller than it need be, but also may be the cause of a shift in the character of the grass strain in favour of the earlier and more vigorous but possibly less persistent elements in the constitution of the strain. To safeguard the character of the strain, the aim is to sow as little seed as possible consistent with a reasonable stand. It is obvious that when conditions of seeding and subsequent conditions for establishment are the best possible, the quantity of cocksfoot or of ryegrass can be as low as 1 lb. per acre. Unfortunately, ideal conditions of establishment and growth cannot be assured in advance, and thus in practice a margin must always be allowed for various contingencies; the more favourable the predetermined conditions can be made, the less is the margin required as an insurance against vagaries of the weather and pests.

The seed grower does not welcome a weedy crop caused possibly by too light a seeding, and the plant breeder looks with disfavour on too thick a seeding that may change the picture he has in mind of the strain that has been built up. Some skill is therefore required in reconciling these two points of view. The seeding generally is approximately 1 lb. per acre less than for third-multiplication sowings when the sowing conditions are favourable.

FIG. 3. Foreground. Drying of sheep's fescue S.58 seed crop on poles. Sheaves held on stiff wires driven through pole.

Background: Red fescue S.59 seed crop drying in stooks.



FIG. 4. Second stage multiplication of bred strains:

(a) foreground: timothy S.51.

(b) background: perennial ryegrass S.23.

(c) left: cocksfoot S.26.

All grown in 2 ft. drills without a cover crop.



FIG. 5. Third stage multiplication. Cocksfoot S.26 harvested for seed on a field scale. 800 ft. elevation in Wales; yield 640 lb. per acre.



4.—THIRD STAGE MULTIPLICATION.

A.—SELECTION OF CENTRES.

CHOICE OF DISTRICTS.

Several considerations are kept in mind in choosing areas for the second and third multiplication stages. As several strains of each species have to be multiplied simultaneously, it is not possible to have all the strains at either stage grown for seed on the Station's farm. Contracts are made with a considerable number of growers, and the first consideration is to have the seed production islands at distances within reasonable reach of the Station, so that the Station's staff can exercise proper control over them. While a few of the smaller islands are contracted for within five miles of Aberystwyth, the bulk of the propagation areas are selected in the border counties. Areas are found in these counties with better soil, climatic conditions and isolation than are available on the west coast of Wales. For various reasons preference is given to farms which fall in groups within the favoured districts.

CLIMATIC CONDITIONS.

Moderate and well-distributed rainfall, together with maximum sunshine, are the desiderata for good quality seed and heavy yields in Great Britain. These conditions are obtained in a large measure in most of the counties in southern England and certain areas in Scotland and Wales. The average annual rainfall in these favoured areas ranges from just over twenty inches in the east to about thirty-five inches in some of the western counties. The difference between the rainfall of these areas during the summer is significantly less than these figures suggest, on account of the greater winter rainfall in the west.

Although the rainfall tends to increase and sunshine to decrease with altitude, altitude in itself appears to be no safe criterion for choosing suitable seed production areas; for instance, in Montgomeryshire, on the eastern side of the Welsh mountain massif, prolific and high-quality seed crops of leafy strains of cocksfoot and timothy have been obtained at an elevation of over 800 ft. above sea level. On the seaboard side of the massif, apart from the question of soil, the climatic conditions are so different that seed production is entirely out of the question at a similar elevation.

SOIL.

Deep medium loams in a high state of fertility are naturally well suited for the seed propagation of most grass strains; such soils are the most dependable for seed crops in all types of seasons. Heavy and sandy loams can produce very satisfactory seed crops; they can be as productive of seed in certain strains as the medium loams, and are in certain respects even better.

For drill culture heavy soils are quite unsuitable, owing to the difficulty in obtaining adequate inter-drill cultivation, and in fact to the impossibility of effecting any sort of cultivation during exceptionally wet seasons. Stiff loams are admirably suited for those grass strains which are known to produce heavy yields of seed when broadcast; strains of ryegrasses and red fescues are in this category. Light loams and sandy soils, provided the subsoil is satisfactory for drainage purposes, are the most easily cultivated and thus can be usefully employed in growing those grass strains which require drill culture for seed production.

Soil fertility can be more easily controlled in the lighter loams and sandy soils, and for this reason such soils are preferable to the rich loams for propagating the seed of some strains, more especially those exhibiting strongly creeping habits.

In excessively wet seasons creeping strains of red fescues grown on rich loam soils are apt to develop excessive vegetative growth and suffer reduced seed yield even without the application of fertilizers. Even non-creeping strains with a tendency to extreme leafiness are prone to excessive vegetative growth in wet years when grown on the heavier and richer loams. This exuberance of leaf at harvest time is a condition which the skilful seed grower wishes to avoid, as poor seed yield is usually associated with it, and it interferes very seriously with harvesting, field conditioning and threshing.

In brief, the question of soil for the production of seed from grass strains resolves itself into utilizing (a) the heavy loams for broadcast stands of *Lolium* species, and, when the land is exceptionally clean, for red fescue strains; (b) the medium loams and light loams for most strains which produce the most economic crops when grown in drills which allow thorough cultivation, and (c) the lighter loams and sandy soils for strains which are apt to develop too much leaf on the rich loams.

PREVIOUS CROPS.

Three points which must be kept in mind in considering previous crops are their effect on (1) soil fertility, (2) general cleanliness of the land, and (3) seed content of the soil. For the purposes of raising stock seed of high standard, the weed seed content of the soil is obviously important; soil fertility and the eradication of such weeds as couch (*Agropyron repens*) and thistle (*Carduus* sp.) are, by comparison, problems which can be solved more easily. Soils known to be heavily contaminated by viable seeds of miscellaneous grasses and noxious weed seeds such as dock (*Rumex* sp.) cannot be regarded as suitable for the growing of satisfactory stocks of pedigree grass seed. It is obvious that an enquiry must be made into the cropping history of any particular field under consideration for seed growing. An old lowland pasture would be suspect, even though several crops had been taken since it had been brought under the plough; such arable land frequently inherits a prodigious number of buried seeds and the seed grower is often dismayed by the tenacity of life displayed by buried seeds after continuous cultivation for some years.

In arable land, the weed seed content of the soil varies with the type of soil. One of the most troublesome plants of the heavier soils is the annual, slender foxtail (*Alopecurus agrestis*), the seed of which is very difficult to eradicate and persists in the soil for several years.

Another source of soil contamination arises through the taking of grass and clover seed crops, and even the late harvesting of young leys, all of which result in the burying of seed in the soil.

Other sources of danger to a pedigree seed crop from volunteers may come about through seeds being carried in a viable state in farmyard manure applied directly to the seed crop, or preceding crops, or through shedding of seed from over-matured hay fed to sheep folded on a root crop in the year preceding the sowing of the grass for seed. There can be little doubt but that air currents are capable of transporting grass seeds from one field to another; thus the nearer the source of such seed in previous years, the greater the danger of volunteer grasses appearing in the seed crops.

In order to be entirely satisfied that an area offered for growing stock seed is free from seeds likely to contaminate the seed crop, the soil must be sampled and the seed content examined by germinating the seeds from such samples and growing the seedlings until the plants can be identified.

In general, root crops supplied with generous quantities of organic manures appear to be most satisfactory preparatory crops for grass seed crops. Should a seed grower have occasion to give hay to sheep folded on roots, he should make

certain that such hay was cut before it had set seed, or if the hay does contain any seeds, they are of a type that can be easily separated from the seeds of the grass strain to be grown.

When two cereal crops precede the grass seed crops to be grown in drills, and it is considered necessary to apply farmyard manure, only well-rotted manure is applied.

ISOLATION.

The problem of isolating grasses and clovers for seed production in Great Britain has in the past not received any particular attention by seed growers generally, for the very good reason that there was little or no variation in the types grown for seed, or if, as in the case of red clovers, there were distinct types, they were confined each to a particular district where the variety had the reputation of being the most suitable. This naturally occurring arrangement suggests a practical method of safeguarding the purity of new strains of grasses and clovers.

When the seed is very limited in quantity, as in the second multiplication stage, and the seed island is therefore relatively small, such islands are established on the best isolated fields available. In practice the isolation is found satisfactory when the island of 1 acre to 5 acres is not less than 400 yards from a crop grown for hay or seed which may contaminate the pedigree seed crop to a serious extent. Excellent isolation is found on large arable farms where grasses or grass and clover are omitted from a rotation consisting simply of a root crop followed by two cereal crops. A part of the land allocated for seed production covers the complete rotation during the seeding year and two harvest years.

When a grower wishes to establish a ley on part of the field where a pedigree grass seed crop is to be grown, he is induced either (1) to omit the species to be grown for seed from his mixture, or (2) he is provided, when circumstances permit, with a quantity of the same stock as that to be grown for seed, for inclusion in his mixture. The latter alternative is the most desirable, for not only is the grower allowed to follow approximately his usual practice, but also the effectiveness of the isolation is improved by having an extra crop of the pedigree pollen near the seed island.

Provision for adequate isolation is apt to be more difficult in districts of the British Isles where grass seed growing is of long standing than in districts at least equally suitable for seed production, but where this branch of husbandry has not hitherto been established. Quite apart from the latter consideration, all the stock seeds of Aberystwyth grass strains have been produced for the sake of convenience of supervision in districts having no tradition of growing grasses for seed. Satisfactory isolation is comparatively easily found for strains of cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*), red fescue (*Festuca rubra*) and Yorkshire fog (*Holcus lanatus*) in the counties on the Welsh-English border.

For strains of perennial ryegrass (*Lolium perenne*) the choice of centres providing adequate isolation is more restricted, but as grass seed production develops in these areas, the difficulty of obtaining satisfactory isolation will very largely be eliminated. To this end, the plan adopted is, firstly, to find growers who are prepared to adopt one strain only of ryegrass not only for seed production, but for inclusion in their seeds mixtures, so that in a few years the grasslands of a grower working on this plan will be dominated by one strain of ryegrass. Seed growers who have already appreciated the value of the improved grass strains for their long-term leys are induced without great difficulty to plough up their permanent swards; when these are eventually laid down to grass after a few arable crops, they will be established with the pedigree strain of ryegrass grown for seed. In this matter of isolation for

seed production, the co-operation of neighbours is very desirable; in most cases this desideratum is actively canvassed when it is realized that seed growers who are prepared to plan isolation on sound lines are able to command a premium on their seed.

By encouraging a seed grower to have only one strain of any one species on his farm, and by influencing all the growers in a neighbourhood to adopt the same practice, we arrive at the position which the growers of local varieties of red clovers have enjoyed in regard to isolation. This may entail a certain amount of sacrifice on the part of individual farmers who, for example, may desire an early and a late type of ryegrass in their leys, but when the price of pedigree and certified grass seed is sufficiently attractive, he is more than compensated in the price of seed for having to adjust his farming slightly to conform with the requirements of accredited grass seed production. If ryegrass is the only grass grown for seed in the neighbourhood, the seed grower has the choice of early and late strains of species other than the ryegrasses.

The proximity of pastures containing elements liable to damage the seed of a pedigree strain through cross pollination does not of necessity preclude the growing of a pedigree strain for seed in such a situation, provided the grazing of such pastures is adequate at the material dates of flowering; by grazing alone, or by grazing in combination with cutting, the grass inflorescences are prevented from developing to the flowering stage.

A difference in time of flowering between two strains of the same species is a natural barrier against cross pollination, but although an interval of three weeks may occur between the peaks of flowering, as in a hay and pasture type of ryegrass, there is inevitably a certain amount of overlapping in pollen liberation; hence the need for the grazing animal, and on occasion the mower, to ensure the purity of the strain.

Italian ryegrass (*Lolium italicum*) flowers about two weeks later than a hay strain of perennial ryegrass, and thus is often a greater source of danger to the seed crop of a late strain of perennial ryegrass. This short-lived ryegrass throws up inflorescences so vigorously and persistently at the height of the growing season that if an adjacent seed island of perennial ryegrass is to be adequately protected from its pollen, the hay crop, if taken at all, is harvested early in June, and the aftermath severely grazed and skimmed with a mower at least once. By contrast with the ryegrasses and other species such as cocksfoot and the fescues, continuous close grazing during autumn and spring results in a sward which exhibits little tendency to produce inflorescences, a phenomenon which is naturally most marked in the more leafy strains intended for grazing purposes. Seed growers in planning a scheme of grass seed production turn this fact to useful advantage.

While there is need for adequate spatial isolation between strains of most species to prevent cross-pollination, there are some species in which little or no cross-fertilization takes place, and in which distance isolation can be neglected except in so far as propinquity may result in the accidental mixing of harvested crops, or in the shed seeds of one species falling on the seed island of the other species.

Strains bred at the Station can be classified into four groups in relation to the need for isolation.

Group I includes the following grasses, in which inter-crossing takes place readily between strains of the same species; such strains must be well segregated when grown for seed: perennial ryegrass (*Lolium perenne*), Italian ryegrass (*L. italicum*), cocksfoot (*Dactylis glomerata*), meadow foxtail (*Alopecurus pratensis*), meadow fescue (*Festuca pratensis*), tall fescue (*F. arundinacea*), red fescue (*F. rubra*), sheep's fescue (*F. ovina*).

Group II consists of strains within a species which do not readily cross when grown in close proximity. Strains of smooth stalked meadow grass (*Poa pratensis*), (S.62 and S.63) fall within this category. The diploid strains of timothy (S.50) may be grown near the hexaploid strains of timothy (S.48 or S.51) with little risk of intercrossing. Two diploid strains or two hexaploid strains must, of course, be segregated for seed production similar to those in category I.

Group III. This group consists of genera and species, among which intercrossing is possible, but does not occur readily. Perennial ryegrass, meadow fescue, tall fescue, red fescue and sheep's fescue are included in this group. The distances between islands of these species need not be as great as those in Group I; if blocks of cocksfoot or timothy are grown between them in the same field, bulk multiplication for seed mixtures can be undertaken with safety.

Group IV. The fourth group consists of species which can be grown (one strain of each) in close proximity without any risk of intercrossing: perennial ryegrass cocksfoot, timothy, meadow foxtail, Yorkshire fog (*Holcus lanatus*).

Whenever it is found necessary to have several strains grown contiguously for seed on a farm scale, the relative dates at which they will mature for harvesting are kept in mind, so that as far as is possible they are sown in order of earliness, the earliest types being established on the area nearest a road or gate.

B. FIELD MANAGEMENT.

METHOD OF SOWING.

The two chief methods of sowing the seed of grass strains for the second and third multiplication stages are (1) in drills, having a standard width of 24 inches between them, and (2) broadcast. These methods are varied for some species by sowing the seed either in drills, or broadcast under a cereal nurse crop.

The drill method is adopted almost invariably for the second multiplication islands, not only in order to economize the limited quantities of seed available, but on account of the more satisfactory seed yields resulting from the use of this method for most strains as compared with broadcast sowing. The more leafy and the more adapted for pasture is the strain of cocksfoot or timothy, the less favourable are the seed yields from broadcast areas as compared with stands established in wide drills, and the more rapidly does the seed productivity decline in successive crops. Apart from perennial ryegrass, Italian ryegrass and red fescue, the drill method is employed generally for the third multiplication as well as the second multiplication stage.

Seed rate for drills 2 ft. apart.

		lb. per acre
<i>Lolium perenne</i>	Perennial ryegrass	3—5
<i>Lolium italicum</i>	Italian ryegrass	4—6
<i>Dactylis glomerata</i>	Cocksfoot	3—5
<i>Phleum pratense</i>	Timothy	3—5
<i>Festuca pratensis</i>	Meadow fescue	4—6
<i>Festuca arundinacea</i>	Tall fescue	5—6
<i>Festuca rubra</i>	Red fescue	4—5
<i>Festuca ovina</i>	Sheep's fescue	4—5
<i>Alopecurus pratensis</i>	Meadow foxtail	5—6
<i>Holcus lanatus</i>	Yorkshire fog	3—4
<i>Poa pratensis</i>	Smooth stalked meadow grass	3—4

The lower rates apply more particularly to the second multiplication stage, and when conditions for plant establishment are considered to be favourable. The higher rates are employed for very early sowings, for soils on which the tilth is inclined to be rather rough, and for soils inclined to suffer from drought or continuous wet weather. As some of the seeds in the above list are substantially smaller in size than others, a greater number of the smaller seeds is sown per unit area than of an equal weight of seed of a larger size ; this is offset by the slower development and lower establishment of species with small seeds.

Occasionally one half pound of white mustard is mixed with every five pounds of grass seed, in order that the mustard plants may indicate the drills in a short time for cleaning purposes.

Cereal cover crops have a very depressing effect on the first harvest seed crops of all leafy strains of cocksfoot, timothy and the fescues, when such strains are sown under oats, wheat or barley in spring, and particularly when the grass seed is sown in spring on land sown with wheat in the previous autumn. This depressing effect naturally disappears after the first seed crop, but the reduction in seed yield is so marked in the first seed crop that cover crops are dispensed with in the first and second multiplications of these strains. There is, in addition, always the risk of the lodging of ordinary cereal varieties, endangering a satisfactory establishment of the grass.

Of the species mentioned, strains of timothy suffer less in competition with cereal nurse crops than other species, but a cereal cover crop may depress the seed yield even of a hay type (hexaploid) timothy to about half that produced when sown without a cover crop.

Perennial and Italian ryegrass, even the leafy strains, establish so vigorously and make so much more relative growth during the autumn and winter months than the other species mentioned that they can suffer the influence of a cover crop tolerably well when drilled in such crops during spring. The more, however, the strain of perennial ryegrass approximates to an extreme pasture type, the greater is the retarding influence of the cover crop, a fact to be considered at seeding time, and in subsequent management for the first seed crop. When a cereal is used, the grass seed rate in the drill is somewhat more generous than in drills sown without a cereal, and the greater number of seeds of a pasture type of ryegrass as compared with a hay type in an equal number of pounds compensates very largely for the slower development of such strains and the weaker power of establishment. When conditions are not in every way favourable for plant establishment and for a first seed crop the cereal crop is sacrificed during the seeding year.

Broadcast method. For the third multiplication stage of perennial ryegrass, the broadcast method under a cereal cover crop gives satisfactory results even with leafy pasture strains on land in a good state of fertility. Leafy strains of ryegrass seed are generally sown in spring on about the same date as the cover crop, in the following mixture :

	lb. per acre.			
Perennial ryegrass				25
Timothy (Scotch)				5
Wild white clover				0.5

This seeding rate of ryegrass can with advantage be reduced to 20 lb. or less per acre, when soil conditions are exceptionally good, and the seeding rate of the cereal is reduced to two-thirds the normal rate. The inclusion of a proportion of Scotch timothy seed is of advantage for several reasons ; firstly, it helps to support the rye-

grass, secondly, it facilitates the reaping of short crops of ryegrass, and thirdly, the heads of timothy form a coping to cover the ryegrass heads in the stook. The leafy bred strains of timothy interfere more with the drying of ryegrass crops than the more stemmy Scotch type; when the latter is sown with a pasture type of ryegrass, its seeds mature almost simultaneously with the ryegrass. The seeds of commercial strains of timothy are also more easily separated from those of perennial ryegrass, as they thresh out cleaner from the glumes.

Wild white clover is included in the mixture in order that, after one or two seed crops of pasture types of ryegrass have been harvested, the resulting sward may form a first-grade permanent pasture, and/or occasional seed crops of white clover. White clover seed crops can be taken after the first seed crop of hay types of perennial ryegrass. In the same way, Italian ryegrass, sown broadcast under a cereal, with a small proportion of wild white clover seed added, can give excellent first harvest-year crops of seed followed by wild white clover seed crops in the second harvest year.

Creeping red fescue sown broadcast under a stiff-strawed cover crop produces satisfactory seed crops on land free from coarse grasses and noxious weeds. Eighteen pounds of good quality seed per acre is an ample seeding rate on land which carried a root crop in the previous year, provided that a satisfactory tilth is obtained and the cover crop is sown at a reduced rate. Although suitable land in a district of low rainfall may be obtained for broadcast stands of red fescue for seed production, the wide drill method is adopted if there is any danger of the appearance of grass volunteers such as ryegrasses, cocksfoot or any other coarse grasses, the seed of which cannot be readily separated from the fine-leaved fescue seed.

TIME OF SOWING.

Drills. Whenever and wherever possible, autumn sowing in preference to sowing in the following spring has much to commend it. When suitable land is available towards the end of August or the beginning of September, and sowings can be made before the middle of September, at least two advantages are obtained. The first is the reduction in cleaning cost of established grass drills, for annual weeds are seldom as troublesome after autumn cultivation of the land as in spring; in addition, the grass seedlings appear in a relatively short time as the seed is sown before the soil has lost its summer warmth. The vagaries of the weather in spring may cause such a delay in brairding that annual weeds frequently make disastrous headway and tend to smother the grass seedlings; much expensive manual work is necessary, if such weeds as species of *Chenopodium* and *Polygonum* are present in quantity. In order that horse hoeing can begin at the earliest possible moment, a mustard indicator is used, more especially with the slower establishing pasture strains and fine-leaved fescues. With sufficient moisture in the soil, the mustard seedlings make the drills sufficiently distinct within ten or fourteen days to allow the first cultural operations to be made with safety. No difficulty is experienced with the mustard indicator after the autumn sowing, as the plants appear only at a frequency of about one per linear foot, and in average years disappear entirely during the winter months.

Just as weather conditions for the germination and brairding of grass seed may be problematical after spring sowings, so can they affect subsequent growth. When conditions make it difficult to obtain as good a tilth as desirable for spring sowing, and an exceptionally dry summer follows, slow-developing strains may be so handicapped that they are unable to make sufficient growth before autumn to warrant the expectation of a normal seed crop in the first harvest year. Leafy strains of fescues and cocksfoot are peculiarly influenced by such unfavourable conditions, and for all the strains which are very sensitive to growth conditions in their early stages, early

autumn sowing provides a considerable measure of insurance for a satisfactory first harvest seed crop (see Figs. 6 and 7). It must be realized that the depressing effect of slow development in the seeding year on the first seed crop does not necessarily continue into the second harvest year (see Fig. 8).

Seed growers have to be reminded that these autumn sowings are not in place of sowings in the *previous* spring, but serve as useful alternatives to sowings in the *following* spring, and that therefore they are not to expect seed crops during the year immediately following autumn sowings. Of the species bred at the Station, only the ryegrasses exhibit a propensity for seed production in the year following autumn seeding. For stock seed purposes this practice is not followed, as these are cross-fertile strains within which there must inevitably be a certain range of variation in earliness and persistency. Therefore, a seed crop harvested in the year after sowing would tend to have an undue proportion of the early types within a strain, and if used for propagation would cause the strain to lose a certain amount of its original character. Seed produced in this manner from well-bred strains can be used if employed for seeds mixtures directly, and not for further multiplication. This procedure would have more serious repercussions on the constitution of an *unbred* strain, such as ryegrass from old pastures. Under favourable conditions, it is possible to obtain seed yields of ryegrass in the season following an autumn sowing to remunerate the grower quite handsomely.

The general policy indicated by experience at the Welsh Plant Breeding Station is to take advantage of land freed early from a root crop, or an early cereal crop on really clean land, to prepare the ground for sowing grass seeds in early autumn. Satisfactory establishment can be obtained even when sowing has been delayed until the first week of October, but in that case the seeding should be more generous than is usual for spring sowings, to allow for winter killing of seedlings. Ryegrass can be sown somewhat later than most other species, but as the month of October advances, conditions for seed establishment are inclined to deteriorate rapidly. A common experience after late autumn sowing is uneven establishment by early spring; this need not disturb the seed grower unduly, as there are usually sufficient unbraided seedlings which make their appearance by the end of April to even up the drills. It will be realized that the sowing of these grasses in wide drills for seed production can be delayed later than would be safe with seeds mixtures; the seeding rate in drills may be sufficiently heavy to allow for as much as 75 per cent or even more casualties without detriment to the final establishment for seed production.

Autumn sowing may offer another advantage which is now being studied at the Station. As previously indicated, several grass species are susceptible to the competitive influence of a cereal nurse crop when such grass species are sown under spring varieties; when leafy strains of cocksfoot, timothy and fescue are sown without a cover crop, the seeding year brings no return to the grower. From evidence now becoming available it would seem that a leafy strain of cocksfoot, for example, can be sown in early autumn under a cover crop of a short-strawed winter oat. This type of oat is now under test for this purpose; it has several advantages as a nurse crop for grasses sown in drills. It grows to little more than 3 ft., and its straw allows light to penetrate to the grass seedlings. The straw is exceptionally resistant to lodging, and the grain yield compares favourably with yields of other varieties of winter oats. In order further to favour the development of the grass plants, it is advisable to arrange sowings so that three drills of oats alternate with one drill of the grass, when 6 inches is allowed between all drills. There are thus 24 inches between each grass drill and these have a space of 12 inches between two drills of oats. By this arrangement it is possible with a little care to apply a fertilizer to stimulate the growth of the grass without at the same time stimulating the cover crop.

Effect of sowing dates on subsequent seed crops.

FIG. 6. The effect of sowing dates on first harvest seed crops of cocksfoot. Sowing dates, right to left.

- (a) mid-September, 1929.
- (b) first week October, 1929.
- (c) mid-June, 1930.
- (d) first week July, 1930.

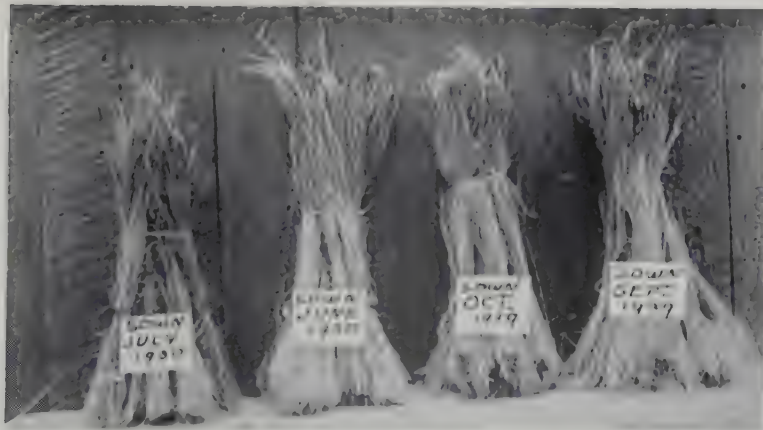
Samples represent crop harvested 1931.



FIG. 7. Sheep's fescue S.58 sown as cocksfoot in Fig. 6 and harvested 1931.



FIG. 8. Sheep's fescue S.58 as above, showing samples representing second harvest year seed crops 1932.



A short-strawed winter wheat, comparable with the short-strawed oat, is also available, but for various reasons wheat is not quite as good a nurse crop as oats. At the moment there are no spring oats with quite as stiff and as short a straw as the winter oats; although there are relatively short spring varieties of barley available, this crop is notoriously prone to lodging, even if it is in other respects a very suitable nurse crop.

Spring sowings are made from the beginning of April to the beginning of June. The date of seeding within this range of dates is determined very largely by (1) weather conditions, which govern the working up of suitable tilth in any given type of soil, (2) the incidence of annual and other weeds in the soil, (3) whether a cover crop is to be used, and (4) the species to be seeded.

The range of dates for sowing ryegrass is wider than for strains of other species; if perennial ryegrass is to be sown in wide drills under oats or barley, the seed can be sown with safety towards the end of March, at the same time as the cover crop. At the other extreme, strains of this species make sufficient headway by autumn even when sowing is delayed well into June, in which case a cover crop is omitted.

The range of dates for sowing strains of cocksfoot, timothy and the fescues is limited, possibly on account of the need for finer tilth and higher soil temperature than for ryegrass. The slower the rate of development of a strain, the more susceptible is it to the influence of drought; hence the danger of delaying the sowing of leafy pasture types beyond May, particularly in districts of low rainfall. Poor growth of these species in the seeding year invariably results in poor first harvest-year seed crops.

Broadcast sowings. As the broadcast method is applied to ryegrass only in the third multiplication stage, it is accomplished in association with cereal crops in order to reduce production costs. It is found necessary to synchronize the sowing dates of pasture strains of ryegrass and the spring cover crops in order that the grass is given the maximum opportunity to compete with the cover crop. An extremely poor establishment may occur by delaying the seeding of these types until the cover crop is well up, as is the custom with commercial perennial ryegrass in the older seed producing districts of the British Isles. Owing to their slow rate of development in the first few months, pasture strains of perennial ryegrass do not interfere with the harvesting of the nurse crop to the same extent as the ordinary hay strains. There is therefore little reason to follow the old practice of delayed sowing; indeed it involves not only poor establishment but waste of good seed, for even doubling the normal seed rate may not be sufficient to secure the establishment to be expected from simultaneous sowing.

If the sowing of cereal and grass seed is delayed until April, the chances for conditions to provide good tilth and warmer weather for rapid establishment of the grass seeds are increased, and the rate of seeding can be correspondingly reduced.

With Italian ryegrass it is possible to broadcast the seed in a short, stiff-strawed winter oat, during the month of September, and to produce a mixed crop of both in the following summer. For reasons already indicated, this method is not used for producing stock seed of Italian ryegrass, but it is a cheap, economic and easy way of multiplication for ordinary seeds mixtures. The oat crop supports the ryegrass, and being rather shorter does not interfere materially with its pollination and ripening.

TILTH.

Grasses require a deep, fine mould, even if not as firm as that required by the clovers. The plough is not spared in the preparation of a good seed bed. Species other than ryegrasses are rather exacting in the matter of soil conditions; for rapid

establishment they require a fine moist mould recently turned up by the plough. The sowing of these strains should be delayed until the soil can be worked up into a fine tilth, bearing in mind that too late a sowing can be even more prejudicial to a seed crop than too early a sowing.

Normally the last operation before the actual sowing is rolling with a flat or Cambridge roller, the latter being used across the direction in which the seeds are to be drilled, in order to facilitate straight drilling.

SOWING MACHINERY.

Drills. For the second and third multiplication crops sown in wide drills, small hand drills are used to sow on a flat surface. These drills are easily adjustable for the various types of seeds, and one man can with ease sow 2 acres per day in drills 2 feet apart. Three hand drills are employed simultaneously to sow areas up to 6 acres of stock seed, but for large areas the seed grower himself employs either a root drill adapted for sowing on flat surfaces, or a cereal drill. In either case suitable adjustments are made for distributing the seed at the proper rate, and for width between the drills, which is made as near 24 inches as possible. On occasion it is found necessary to vary the drill width slightly above or below this standard in order to accommodate power tractors for cleaning and cultivating purposes.

It is convenient to sow large areas with drills, sowing the same number of drills as can be cultivated later by a horse or power tractor; if there are occasional deviations from the straight in three or four simultaneously sown drills, their course can be followed subsequently by the same number of power-drawn hoes. Efficient markers on hand drills enable straight drilling to be done satisfactorily.

Broadcast Sowings. Seed barrows are almost invariably used for sowing broadcast stands, although experienced men may broadcast equally as well by hand.

MANAGEMENT IN THE SEEDING YEAR.

Drills without nurse crops. If the land requires a further rolling immediately after seeding, the Cambridge roller is preferable to the flat roller, when the soil is of a type that may easily set hard after heavy rain. Rolling may have to be done afterwards, as long as the seedlings have a tendency to suffer from prolonged drought. Cleaning operations are begun as soon as possible after seed sowing, in order that weeds can be controlled from the outset. Skilful seed growers can often dispense with indicator plants, by thoroughly preparing a suitable seed bed, upon which the grass seedlings grow rapidly. It may be possible to begin horse hoeing narrowly between the marks of the seed drill even before the grass has braided sufficiently to be a safe guide. Care is taken at this stage to prevent soil from falling on young seedlings during cultivation operations. Established plants may negotiate a little soil thrown on them, but seedlings which have just braided cannot do this. Cleaning implements are adjusted to work closer to the grass drill as the seedlings become stronger.

Emphasis is laid on the need for working the cleaning implements between the drills at frequent intervals during the seeding year in order to keep weeds under control. Hoeing with horse or tractor-drawn implements is easily and rapidly done when three or more drills are cultivated simultaneously, and when the work is begun early. Some of the more ingenious growers find very soon that they can dispense with horse power, even if they have not the advantage of tractor power, by adapting old motor cars and multiple hoes for the work, although many prefer to exercise a little extra care during the early cultivations and use horse power for the purpose.

The suppression of annual weeds in the grass drill itself requires careful attention,

for they may smother, or at least retard the development of the grass seedlings. Hand hoeing is perhaps the most reliable method for relatively small areas of special stocks, but this is rather expensive for larger areas.

For grass crops which respond quite readily to a nitrogenous fertilizer in the production of seed, an application of from 1 to 2 cwt. per acre of calcium cyanamide has been used effectively to suppress annual weeds and at the same time to stimulate the grass. Care is taken that the grass seedlings are well established before applying the fertilizer, which is done when the dew is on the ground. With an ordinary fertilizer distributor, it is a good plan to roll a length of wire netting, and attach it to the distributor so that the fertilizer falls through the roll before it reaches the ground; more even distribution of the fertilizer is obtained in this way. Undoubtedly the best method of applying a weed suppressor of this kind is by the use of a powder blower. Much smaller quantities are required when a blower is used.

Liquid sprays carefully handled also provide economic and efficient means for eradicating annual weeds when they threaten to become troublesome. A 7 per cent solution of sulphuric acid, applied at the rate of 100 gallons per acre two to three months after sowing, is efficacious in suppressing most annual weeds common on arable land, without more than temporarily checking the grass seedlings. Sodium chlorate and arsenic pentoxide also offer possibilities as liquid sprays for weed suppression. The latter has the reputation of actually stimulating grasses after a temporary setback following the application of the liquid spray.

Should an indicator plant such as white mustard (*Brassica alba*) be used it is necessary to cut the plants down at least once, as they will interfere unduly with the grass if they are at all thick in the drills. A grass mower is used for the purpose. If the grass is well established a flock of sheep may be run over the drills to graze the mustard with advantage to the sheep and to the grass.

Noxious perennial weeds, in particular dock and volunteer grasses, must be removed from the grass drills during the summer months by manual labour.

Drills and broadcast stands under a cover crop. After the cereal cover crop has been removed, the grass rows are cultivated at the earliest opportunity. The task confronting the seed grower who is cultivating drills sown in a cover crop is rather different and generally more difficult than when drills are grown without a cover crop, as the soil undergoes much consolidation from the time of sowing to the time of harvesting of the cereal. In light, dry soils horse hoes with chisel tines may do the work admirably; on less tractable soils it is often found necessary to use a plough in the first instance between the drills, with or without its mould board removed. Chisel-tined horse hoes are then able to work up a reasonable tilth at greater depth with each operation. It is desirable to leave the soil between drills of all grass seed areas in a somewhat rough state over the winter, for the purposes of drainage and aeration, and to facilitate the working of tined implements in early spring. A similar purpose is achieved by running the ridging plough between the drills, but not so deeply as to cause earthing up of the plants.

Broadcast stands require little cultural operations in the year of seeding after the cover crop has been removed, except for the ruthless roguing of undesirable plants. Consolidation is not generally required, and, in the case of a ryegrass-white clover stand, any operation calculated to encourage an undue proportion of clover must be avoided.

MANURES AND FERTILIZERS.

Grass species vary considerably in their need for fertilizers in relation to seed production. Unquestionably the master factor in any scheme of manuring grasses for seed is nitrogen, whereas phosphates and potash are required to a much more limited extent (see Figs. 9 and 11).

Stiff-strawed species such as cocksfoot and timothy are less susceptible to lodging than ryegrass and the fescues, and larger quantities of nitrogen can be applied to them for the production of seed.

Stoloniferous species and strains do not respond to nitrogen to nearly the same extent as species with a tufted habit in the matter of producing seed (see Figs. 9 and 10); in fact, a good deal of caution must be exercised in applying fertilizers to such strains as creeping red fescue, and such species as smooth stalked meadow grass (*Poa pratensis*). The application of nitrogen may quite as often result in a 50 per cent decrease in seed yield of these types, as it may show an increase.

Leafy strains show even greater seed response to nitrogen than ordinary commercial varieties, when it is applied at the proper time and in appropriate quantities. The aim of the skilful seed grower is to convert every leaf shoot into a stem shoot, and this he can very largely do in favourable seasons by the judicious use of nitrogen. Even the typically leafy pasture strains can be induced to become coarse and stemmy in the hands of the experienced seed grower. The coarser and more stemmy a leafy strain can be made, the more seed it can produce. The informed seed grower knows that the use of measures adapted to induce a pasture strain to produce seed abundantly does not change the essential character of the strain for pasture purposes.

In planning a scheme of nutrition for seminal reproduction in grasses, the current fertility of the land, the type of soil, the average rainfall, and the age of the stand all have to be considered, as well as the species, and growth habit of the strain.

Drills in the seeding year. In practice, land growing a root crop in the year preceding the sowing of the grass drills without a nurse crop is in a good state of fertility and does not usually require a fertilizer during the seeding year. If for any reason the growth of the grass is not satisfactory, a nitrogenous fertilizer must be applied.

The degree of development of the grass in the drills by autumn will determine very largely the size of the seed crop which will be produced in the following years. In all the strains for which drill culture is necessary there must be an abundance of tillers by the autumn to ensure a normal seed crop in the following year. Such tillers should preferably not be very forward in growth; they appear to resist the rigours of winter conditions better in a comparatively young, short and sturdy stage of development.

When farmyard manure is available and the land is not considered to be in good heart, the seed grower is advised to give a moderate dressing of from 10 to 15 tons per acre. Care must be taken to ensure that the manure used contains no viable seeds likely to prejudice the seed crop. Some growers prefer to apply farmyard manure on ridged land, and to sow the grass seeds on ridges after splitting the original ridges over the manures. The roller is used to make the final ridges relatively shallow.

If farmyard manure is not available, a generous quantity of a complete fertilizer should be applied at seeding time when the cropping expectation is low. A top dressing of nitrogen is applied afterwards to the established seedlings if and when indicated. Various strains of ryegrass species are more exacting in their demands on soil fertility than strains of most other species; thus, if the cropping expectation of the land is low, the seed grower has to build up fertility correspondingly. The fine-leaved fescues, at the other extreme, produce relatively much better seed crops under conditions of low expectation than the ryegrasses, cocksfoot and timothy. If, therefore, the fertility is not present, it has to be introduced, or species which make relatively light demands on fertility must be grown. In general terms, it may be said the more leafy the strain, the higher should be the soil fertility.

Drills in the Spring of the first harvest year. If fescue species, and especially strains exhibiting a creeping habit are to receive fertilizers at all, they must have the

Effect of fertilizers on the seed production of different species.

Rates in cwt. per acre : superphosphate (P)=3 ; potash salts (K)=2.5 ; nitro-chalk (N)=3.

FIG. 9. Cocksfoot S.26. Seed yield in lb. per acre (dry year).

- (a) Control=152
- (b) PKN =303



FIG. 10. Red fescue S.59. Seed yield in lb. per acre (dry year).

- (a) Control=160
- (b) PKN = 73



FIG. 11. Showing that nitrogen is a master factor in seed production of cocksfoot. Seed yield in lb. per acre (dry year).

- (a) Control =236
- (b) Nitrogen=530



greater proportion in the year preceding the seed crop. Applications of nitrogen in spring tend to favour leaf development in these types, more especially when they are grown on fertile land in districts of relatively high spring and summer rainfall.

In terms of averages, a quantity of nitrogenous fertilizer up to 2 cwt. per acre applied in spring is found to produce the best results for first seed crops of cocksfoot and timothy strains. Ryegrass strains under the same conditions are given rather less nitrogen, if lodging is to be avoided. When lodging in ryegrass occurs late, or within a week or two of the harvest, it is not in itself detrimental to seed yield; provided that it is not severe and does not interfere unduly with the most economical method of harvesting the seed, it is a welcome sign to the seed grower.

Nitro chalk is the form in which nitrogen is applied generally to all grasses cultivated in drills for seed. This fertilizer gives the best results when applied to the drills from the end of March to the first week in April. In contrast with wheat, these perennial Gramineae tend to utilize late applications of nitrogen for leaf shoot production. Obviously early species and early strains of a species can make better use of an earlier application of nitrogen than late species and strains, although it must be borne in mind that the strain which is earliest to ripen its seed is not always the earliest to begin growth in spring. An outstanding example of this is the Station's hay type timothy, S.51, which begins active growth a week or two earlier than the ordinary commercial strains, but is at least one week later in ripening.

Successive seed crops in drills. Manurial requirements naturally increase with increasing age of the stand cultivated for seed, and for grasses the greatest need is for increased quantities of nitrogenous fertilizers. Approximately 1 cwt. per acre of nitro chalk is invariably applied to all cocksfoot and timothy strains in the early autumn (September) after the first seed crops have been harvested, and crops to be harvested for seed after the second of such crops may receive upwards of 2 cwt. in the autumn. Much depends on the summer weather conditions influencing the previous crop. The effect of a generous dressing of nitrogen applied to a seed crop in the spring is distinctly seen in the excessive numbers of leaf shoots in the aftermath when the weather conditions during late spring and summer are exceptionally wet; consequently in such circumstances there is less need for autumn manuring. On the other hand, when the conditions are favourable for the utilization of nitrogen to develop the reproductive phase to its fullest extent, very few leaf shoots remain at harvest time to produce the next seed crop. The need for ample nitrogen is then indicated to stimulate an abundance of leaf shoots before the winter sets in.

Even the fescues and stoloniferous types react favourably to nitrogenous fertilizers subsequent to the first and second seed crops, but greater reliance should be placed on an autumn application than on spring applications, although a proportion of the fertilizer is permissible as a spring dressing. For the strains most responsive to nitrogen the greater proportion of the total application is reserved for the spring. Upwards of 3 and even 4 cwt. per acre of nitro chalk are used in spring for these strains, chiefly cocksfoot and timothy on the less naturally fertile soils.

Perennial ryegrass strains in drills also require heavier applications of nitrogen for the second seed crop, and the autumn application of the fertilizer is even more important for them than an application in the following spring. Quite 2 cwt. per acre of a nitrogenous manure are applied within a month after the first seed crop is harvested, followed by from 1 to 2 cwt. per acre in the spring.

Of the species of grasses dealt with here, the ryegrasses are the most difficult to maintain satisfactory seed yields from drills in successive years. There are strong indications that lime increases the longevity of ryegrass strains. Adequate lime in the soil, stock treading of stubble, rolling, stubble burning and generous applications of fertilizers are calculated to increase their longevity in drills.

Applications of mineral fertilizers, phosphates and potash, do not greatly influence the seed yields of grass species in the first crops on average fertile arable land. When successive seed crops are taken, however, and heavy applications of nitrogen are made in spring and autumn, light dressings of mineral manures should be given at least every second year.

The addition of farmyard manure seems to be indicated for the third seed crop at the latest, not only for plant nutrition, but also to improve the mechanical condition of the land, water holding capacity of the lighter soils, and drainage in the heavier soils. When a good dressing of this manure is applied, artificial nitrogen can be reduced.

Broadcast stands. Broadcast areas of grasses grown pure for seed make greater demands on fertilizers than drill-sowings of the same grasses. Continued and thorough inter-drill cultivation make more nutrients available than with broadcast stands devoid of clover on the same type of soil.

In the case of pasture plants of perennial ryegrass a quantity of wild white clover is normally sown with the grass; the manurial needs of the grass seed crop are then somewhat different from those of ryegrass in drills. The manuring must stimulate the grass without encouraging the clover unduly and therefore sulphate of ammonia is preferred to nitro chalk as a source of nitrogen. When the white clover has made a strong establishment relative to that of the ryegrass, 1 to 1.5 cwt. sulphate of ammonia are applied at the earliest opportunity after the cover crop has been removed to bring the grass forward as quickly as possible. There may be sufficient growth in the following spring to dispense with further manuring for the first seed crop, but if growth is backward 1 cwt. or more per acre sulphate of ammonia is applied. The need for spring applications of nitrogen is indicated except on very fertile land. By virtue of the clover content of the sward the demand for nitrogenous fertilizers is significantly less than in the clover-less stands. Excess of clover is to be avoided in order to facilitate harvesting the grasses into sheaves by machinery. Apart from manuring, measures tending to control the clover include judicious grazing or absence of grazing, avoiding harvesting the cover crop too early, and avoiding cutting the cover crop too low; in fact, management calculated to shade the grass and clover seedlings checks the clover rather more than the grass.

Heavy applications of phosphates and potash before sowing are not required. They may induce excessive clover growth, but these elements, nevertheless, must not be neglected, if several crops of ryegrass seed are to be taken from the same stand.

Greater care in respect of the control of clover and autumn manuring is necessary with the more leafy and slow establishing pasture strains of ryegrass, than with the more aggressive hay strains of perennial and Italian ryegrass.

Broadcast stands of red fescue do not include sown white clover, and normally do not require any fertilizers, artificial or otherwise, for the first seed crop. For the second seed crop an application of calcium cyanamide in early autumn is recommended, but no spring applications of fertilizers are generally advisable. Third and subsequent seed crops benefit from autumn and spring applications of nitrogen. The fine-leaved fescues do not exhibit a heavy demand for phosphates and potash for the first and second crops of seeds.

GRAZING.

Judicious grazing of grass seed islands not only enables the seed grower to provide excellent fodder in lean periods, but can be beneficial to the seed crops. Strains of perennial ryegrass, particularly when sown broadcast with clover, afford much useful fodder for grazing before the stand is closed for seed. If winter grazing is

Three stages in the development of a cocksfoot (S.26) seed crop.

FIG 12. Mustard seedlings functioning as indicator plants in 2 ft. drills, one month after spring seeding of cocksfoot S.26.

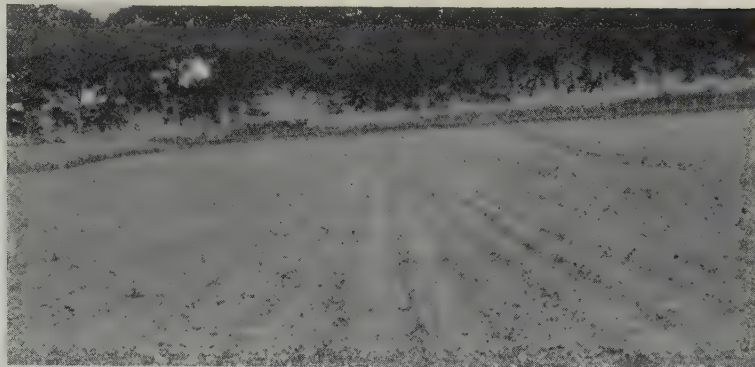


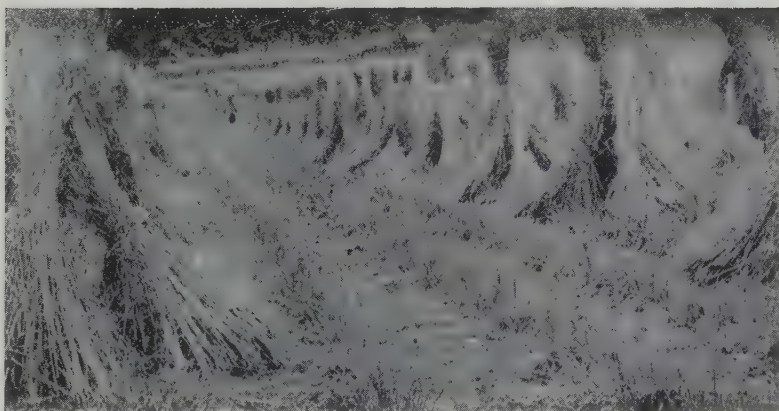
FIG. 13. *Right*: appearance in autumn (October).

Left: red fescue S.59 sown at the same time as cocksfoot S.26.



FIG. 14. As figs. 12 and 13.

First seed crop of cocksfoot (July).



Three stages in the development of a perennial ryegrass (S.23) seed crop.

FIG. 15. Perennial ryegrass S.23 sown in 2 ft. drills. Appearance in May of first harvest year.

Seeding rate in lb. per acre : ryegrass = 5 ; timothy = 0.5.



FIG. 16. Perennial ryegrass S.23 supported by the stiffer strawed Scotch timothy. Appearance in July of first harvest year.

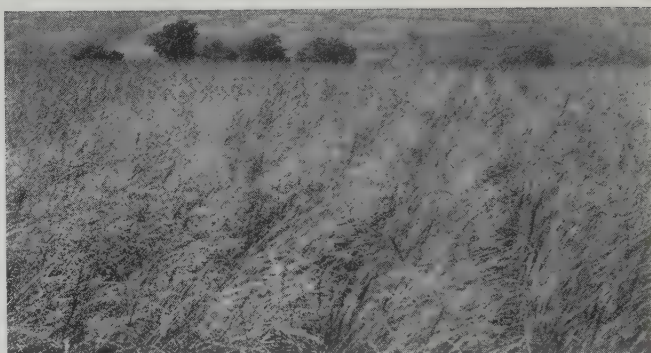


FIG. 17. As figs. 15 and 16.

Harvested first week in August by horse binder.



important to the farm economy of the seed grower, the ryegrass strains require top dressings of nitrogen in autumn and spring, especially the more leafy pasture strains; for those strains in particular grazing should not proceed beyond March. As previously indicated, the grazing must not be so severe as to favour the spread of white clover unduly, otherwise the harvesting difficulties are increased very considerably. Greater caution has naturally to be exercised in the grazing of the less aggressive pasture strains than of the hay strains for first-harvest seed crops. When hay strains of ryegrass are kept for seed beyond the first seed harvest, they require even more careful attention in the matter of manuring and grazing than the pasture strains. For continuous seed cropping of ryegrass, generous manuring and judicious grazing are essential features of sound management.

Cocksfoot, timothy and fescue strains are not normally grazed before the first seed crop is harvested, unless the grass in the drills is very forward by autumn, when light grazing may be permitted with benefit to the subsequent seed crop. The fine fescues are rarely grazed at this stage. For seed crops after the first harvest year light autumn grazing is advisable for most species, when the aftermath is robust. This should be done before the end of September to permit new hardy tillers to develop before winter sets in. The manuring should be such as to make grazing possible with profit. Spring grazing is not recommended for these strains.

All species do not appear to benefit from autumn grazing for seed production. Whereas creeping red fescue responds to autumn grazing, sheep's fescue may suffer a significant decrease in seed yield even when the defoliation is not very severe.

STUBBLE BURNING.

Stubble burning judiciously controlled has a beneficial effect on the seed crops immediately following (See Figs. 18 and 19). The burning is best done as soon as the seed crop has been hauled. Cocksfoot which has its stubble burned fairly thoroughly towards the end of July or the first week in August produces excellent seed crops in the following year. With the surface of the ground dry and the soil reasonably damp, the stubble takes fire readily and the plants under these conditions do not suffer permanent injury. If the burning of cocksfoot stubble is delayed until early spring, a very severe reduction in seed yield will follow.

ROGUING.

Volunteer grasses and vicious weeds are uprooted and removed before harvest, the most convenient time for most crops being before the shooting of the inflorescences. Perennial and Italian ryegrass volunteers are much more easily seen and removed from red fescue and cocksfoot stands during February or March than later. On the other hand, volunteers such as Yorkshire fog and brome grasses can be easily distinguished in ryegrass stands after the inflorescences have emerged. They can be removed conveniently from ryegrass drills, but roguing in broadcast stands is less convenient if the seed crop is well in head.

Thorough roguing necessitates that the areas should be done carefully at least twice, as rogues and noxious weeds continue to appear until harvest.

Greater emphasis is laid on obtaining clean crops on the field than on expensive cleaning machinery capable of removing any and every sort of impurity from the seed. Growers generally are realizing considerably higher prices for their clean stocks, and this has stimulated efforts to produce clean crops on the field.

Inflorescences in the hedgerows and in the vicinity of the seed area, the pollen of which is likely to contaminate the seed crop, are cut before they flower.

C. HARVESTING.

Grass seed crops in the main ripen conveniently between hay and cereal crops, and only in particularly wet years is there a tendency for the harvests to overlap. New growers have to be impressed with the need for very careful attention to grass seed crops as they approach maturation. A week or more may make no serious difference in an oat or wheat crop after it has become reasonably ripe for harvesting, and a hay crop is not seriously damaged through being mown a week or so beyond the optimum stage for cutting. Grass seed crops may suffer disastrous loss of seed through neglecting the harvesting for a similar space of time after the crops have matured. Some species are much more susceptible than others to the effect of wet weather and storms, and the seed grower must exercise proper care accordingly.

As grass seed crops as a whole are not so uniform in ripening as cereals, greater judgment is required in determining the optimum time for harvesting. It is obvious that a proportion of the seed will be unripe if the crop is cut before any seed has shed from precocious heads, and the problem is to have the maximum of ripe seed with a minimum of shedding. In practice, as soon as a small proportion of seed is shed, or if the weather conditions have been calm for a number of drying days, the seeds come away fairly easily when a bunch of heads is drawn through the hand; no time must be lost before the crop is harvested into stooks.

INDICATIONS OF MATURITY OF DIFFERENT SPECIES AND STRAINS.

Perennial and Italian Ryegrass.

Strains of perennial ryegrass vary in appearance when they are ripe for harvesting. The straw of the hay strains is greenish yellow and the heads a greenish brown colour. When a few heads are drawn briskly through the hand seeds come away fairly easily. The experienced seed grower says of ryegrass "the more that sheds the more you get," thus emphasizing the need for at least a little shedding.

The straws of pasture ryegrass are much greener at harvesting than those of hay strains, and thus present a more deceptive appearance. Italian ryegrass has also somewhat greenish straw at harvest.

Cocksfoot.

The straw of cocksfoot is yellow below the panicle and the heads are fairly uniform light brown in general appearance. A slight greenish tinge remains on the seeds when they are ripe for harvesting, and a proportion of seeds comes away when a few heads are grasped in the hand; signs of a little shedding are observed between the rows at this time.

Timothy.

The heads of timothy turn brownish yellow towards harvest, becoming lighter in colour as they mature. Perhaps greater care has to be observed in determining the proper time for harvesting timothy than for other species, and this is more true for leafy strains than for the ordinary stemmy types. The seed grower of Northern Ireland says of his ryegrass seed crop, "You look at it to-day, and it's a day too soon to cut, and you look at it to-morrow and it's a day too late," an exaggeration which stresses the fact that the true latitude between loss from early harvesting and late harvesting is relatively narrow. Leafy timothy seed crops do not thresh well if cut too early, while if a ripe crop is subjected to wet weather and a gale, much of the seed is stripped. Bearing these extremes in mind, it is usual to allow a certain amount of seed to shed from the tips of the forward heads before cutting the crop. The majority of heads should lose almost all trace of greenish colour, as should the seed when rubbed out by hand. The more leafy and more suitable for pasture conditions is the strain of timothy, the greater the need for thorough ripening in the field before harvesting.



FIG. 18. Burnt stubble a few days after harvesting the first seed crop.



FIG. 19. Second seed crop of cocksfoot from same area, after stubble had been burnt in the previous August.

Mechanized harvesting of pasture strains.

FIG. 20. Seed crop of perennial ryegrass S.23 grown broadcast and harvested by a power binder in a wet season (1936).



FIG. 21. Seed crop of creeping red fescue S.59, grown in drills 2 ft. apart, and harvested by a power binder in a wet season (1936).



The large fescues.

Leafy strains of meadow and tall fescue have somewhat greenish straws and greenish brown heads when they are ripe for cutting. In fact they are apt to deceive a new grower and cause him to delay the harvest unduly, with the result that much loss through shedding occurs after the crops have turned colour. These fescues dry quite well in the stook when they are cut before they have altogether lost their green colour.

Red fescue.

The stems become yellowish and the heads purplish brown at harvest time. It is advisable to cut the crop before it has lost the purple colour altogether. Fine-leaved fescues ripen quite uniformly. They dry very rapidly in the stook and no difficulty is experienced in threshing them cleanly.

Sheep's fescue.

The seed crops are cut as soon as the panicles have turned brown in colour. These fine fescues are less prone to shedding than the coarser species. They are more likely than the latter to have double seeds when harvested too early.

Meadow foxtail.

Meadow foxtail is the least uniform in ripening of all the species under review here. A compromise has to be made in date of harvesting. The earliest heads and the very late heads contain relatively few viable seeds, and the crop is cut when the seeds on the medium maturing heads rub out easily.

Yorkshire fog.

Yorkshire fog is another deceptive grass to harvest, but it is the reverse of the broad-leaved fescues. Plants of this species may appear quite whitish and dried up, dead ripe to all outward appearance, and yet on investigation the paleæ may be found to be greenish and the caryopsis immature.

Sweet vernal.

Unlike Yorkshire fog, sweet vernal may have ripe and mature brown seeds when the heads are still largely green in appearance. There is danger of severe loss of seed occurring through shedding, if harvesting is delayed until the heads become golden. When the majority assume a brownish appearance in the upper third to half of the head the time has arrived for harvesting.

Smooth stalked meadow grass.

The ripe state of smooth stalked meadow grass can be more easily determined than with most other species. At maturity the panicles become brown in colour, and the whole crop matures uniformly. There is very little tendency to shedding, although the seed does not improve in quality by delaying the cutting after the crop has reached maturity.

*Phalaris (hybrids of *P. arundinacea* × *nodosa*).*

At maturity the heads become pale in colour, and the seed hard and grey. It is rather difficult to determine the proper time to harvest the crop as it ripens irregularly and the seeds in mature heads shed very easily.

TIME OF HARVESTING.

Most of the strains bred at the Station, with the exception of timothy, *Phalaris* and sweet vernal, are harvested for seed during the month of July. Their harvesting dates are on the average distributed conveniently throughout the month, and they can be placed in their order of ripening as follows :—

<i>Festuca ovina</i>	Sheep's fescue
<i>Festuca rubra</i>	Red fescue
<i>Alopecurus pratensis</i>	Meadow foxtail (pasture type)
<i>Poa pratensis</i>	Smooth stalked meadow grass
<i>Lolium perenne</i>	Perennial ryegrass (hay type)
<i>Dactylis glomerata</i>	Cocksfoot (hay type)
<i>Festuca pratensis</i>	Meadow fescue (pasture type)
<i>Festuca arundinacea</i>	Tall fescue (pasture type)
<i>Holcus lanatus</i>	Yorkshire fog
<i>Lolium italicum</i>	Italian ryegrass
<i>Dactylis glomerata</i>	Cocksfoot (pasture type)
<i>Lolium perenne</i>	Perennial ryegrass (pasture type)

Sweet vernal (*Anthoxanthum odoratum*) comes for harvest in most years during the third or fourth week of June. *Phalaris* hybrids and timothy strains are harvested during August, from the first week onwards.

Hay strains of all species mature earlier than pasture strains; the difference in time of harvesting is most marked between early and late strains of perennial ryegrass, and also between early and late strains of timothy.

Factors which favour early ripening include a hot summer, light soils, and vigorous plant establishment in the previous year. These may cause several of the earlier species to ripen occasionally towards the end of June.

Ripening is delayed when the stand is poorly developed in the previous autumn, and also by such factors as heavy soils and wet summers. Thus, pasture strains of perennial ryegrass after autumn sowing and an abnormally wet summer may not be ripe until the end of the first week in August, and late strains of timothy may not be in a condition for harvesting until the first week in September.

HARVESTING MACHINERY.

Islands of pedigree grasses in the second and third stage of multiplication are almost invariably harvested by horse or tractor-drawn machinery. Undoubtedly the most successful method is to use a direct power take-off from a tractor to a reaping and binding machine. Such equipment has the necessary speed for the knife to deal effectively with any green foliage in the seed crop.

Horse-drawn binders have also been used successfully, and particularly those with relatively short knife bars. This type of machine is advocated for crops with short straws, rather than machines for taking wide breadths. The self-binders that are used for harvesting grass seed crops are adjusted to turn out sheaves of the narrowest width possible to facilitate drying in the stooks (Figs. 20 and 21). Trays or canvases for catching shattered seed are well worth using for dead ripe crops.

Normally self-binders cut two drills at a time each 24 inches apart, but power binders with an 8 ft. cut, and a power take-off can cut 4 such drills at a time when skilfully managed. After a few preliminary cuts across the drills at either end, the binder travels out of gear along the headland to avoid the bumps in going across the drills, and thereafter cuts only two parallel sides in the direction of the drills.

For harvesting smaller areas, growers use the reaping attachment on the ordinary mower, and bind the sheaves by hand when binders are not available. Only very rarely is a broadcast area cut by an ordinary mower and harvested into small cocks in the manner of hay. The cost of harvesting is thereby reduced when a crop such as lodged pasture ryegrass is to be dealt with, but there is always a danger of losing valuable seed by harvesting the crop in this manner. With irreplaceable stocks an effort is made to bind the crop into sheaves even if it has to be cut with a mower, scythe or even hooks.

FIELD CONDITIONING.

Seed crops are preferably cut in early morning or evening so that as little shattering as possible occurs in the process. A little dew on the crops is thus an advantage, but no crop can be cut when wet from rainfall. Crops thus cut dry on the field in a relatively short period of good weather, strong sun and some wind. The sheaves are put up in fours or fives to form neat stooks tied with binder twine at the top. As far as is possible, all sheaves are immediately put in the stooks after binding. In this condition they can stand gales and a shower or two almost every day and yet be fit to thresh in about two weeks' time. Crops are often threshed successfully in less than a week after cutting, when the weather conditions are quite favourable.

Whatever the weather conditions after harvesting, the crops must be perfectly dry when they are carted into the stack, if they are to stand any length of time before threshing, as otherwise there is serious risk of reducing the viability of the seed through heating or mould attack.

STACKING.

Arrangements are made for threshing the crops as soon as possible after they have been brought under cover. If there is a possibility of the crop sweating in the stack, the sheaves are built into narrow bays, two sheaves wide with the butts of the sheaves outwards, in Dutch or stone barns. There is generally ample barn space for these crops at this period when the intention is to thresh and make room for the incoming cereal crops.

D. TREATMENT OF HARVESTED CROPS.

THRESHING.

The Station sends a team of four men with a peripatetic thresher, driven by an 8 h.p. semi-Diesel engine, during end of July or the first week of August to begin threshing the early seed crops harvested in different counties. Both thresher and engine are transported on a three-and-a-half ton lorry. The thresher has been constructed specially for the work of dealing with pedigree stocks, one of its features being the ease and thoroughness with which it can be cleaned (Fig. 22).

The ordinary transportable grain thresher with minor adjustments, including a few suitable screens and pulleys, threshes crops from large areas in a satisfactory and economic manner. A small winnower, fitted with sieves for grass seeds, is frequently used in conjunction with the corn thresher to dress the seed further. Crops from relatively small areas are threshed quite well by the small fixed threshers still used in many Welsh hill farms. In this case hand sieves or a grain winnower are used to dress the seeds.

In threshing, two points have to receive careful attention; first, the correct adjustment of the drum, and second, the speed of the drum. If the drum is too

close or travels too fast, much of the seed may be shelled out; on the contrary, if the drum space is too wide, or the speed too slow, the seed does not come away from the straw cleanly.

With suitable adjustments the clover huller can be used when convenient to thresh grass seeds, although it takes rather longer than the grain threshers. Whatever thresher is used, adequate measures are taken to prevent contamination by seed left in the thresher from crops threshed previously. Apart from the cleaning of the larger threshers, the first bag of stock seed of a crop is laid aside for seeds mixtures.

HULLING.

Clover hullers have to be used to remove the glumes from crops of the leafy types of timothy from large areas. The process is similar to that applied to white clover, but care must be taken to avoid as far as possible removing the paleæ from the seed.

Crops of the same strain of timothy vary considerably in the proportion of seed that requires hulling. Crops with well ripened plump seed, and those which have had a few showers of rain in the stooks have the smallest proportion of unhulled seed. With the most valuable stocks the crop may be threshed a second time in a few months if the seed does not come away cleanly at the first threshing, without removing the paleæ unduly. The large stocks of timothy threshed by the Station's peripatetic thresher are later passed through the clover huller, if a substantial proportion of the seed remains in the glumes after threshing. Before passing the timothy seed through the hullers, the seed already hulled in the process of threshing is removed, as otherwise their paleæ would be subjected to the rigour of the huller brushes.

CONDITIONING OF THE SEED.

The moisture content of the seed coming through the threshing machine may vary from 13 to 25 per cent or more. A moisture testing machine* is used to determine almost instantaneously whether the threshed seed has a sufficiently low moisture content to justify leaving it in bags after threshing. It is considered safe for the seed to remain in the bags when the moisture content is below 14 per cent.

Stock seed with a moisture content above 14 per cent is spread to a depth of about one foot on a clean, airy floor in a barn, at the particular centre where the threshing team may be operating, until sufficient for a lorry load has been threshed. Then a load of eighty to a hundred bags is transported to the seed house at Station headquarters (Fig. 23). Here the seed is spread in floor bins to a depth of 12 to 18 inches and turned daily until the moisture content has been reduced to well below 14 per cent (Fig. 24). The seed is then bagged up for cleaning and grading during the autumn and winter.

The seed house has three floors and the seed is dried without resorting to artificial heat, by currents of air introduced by louvres under the bottom floor and in the roof, as well as by doors, and windows on each floor. Double doors are installed, the outer made of strong woven wire to admit air and keep out vermin when the inner doors are opened. As there is an interval of at least six weeks between harvesting the earliest and the latest strains, the same bins in the seed house are used for successive lots of seeds.

The moisture content of the seed, as it comes from the thresher, in dry years and in dry districts, is often sufficiently low to warrant the keeping of the seeds in the bags until they are cleaned.

*DAVIES, R. M. The rapid determination of moisture in seeds and other granular substances. *Proc. Phys. Soc.* 44. 231-45. 1932.

FIG. 22. Peripatetic
thresher.



FIG. 23. House for
storing and drying
pedigree grass and
clover seed.



FIG. 24. Bins in house
figured above, for
seed conditioning.



SEED CLEANING.

Apart from the special huller already described (p. 9), only one type of machine is used for dressing all the grass seeds produced at the Station. The essential features of the machine are (1) a variable blower, (2) a set of reciprocating screens to make separations according to width of seeds, and (3) two indented cylinders to make separations according to seed length. An extra cylinder replaces the lower cylinder for cleaning timothy seed.

It is obvious that if the work of roguing seed crops has been done thoroughly on the field, the loss of good seed entailed in passing through cleaning machinery is considerably reduced. Thus, all dock seeds present in a stock of pasture ryegrass become included in the small ryegrass seed picked up by the top cylinder of the machine. By removing the dock from the standing crop, the seed grower makes it possible to utilize such valuable seed on good lowland soils, but the inclusion of noxious weed seeds of this type makes considerable quantities of seed valueless unless they can be used to reclaim mountain land generally too poor to support them.

SEED STORING.

There is reliable evidence that seed viability is maintained for a considerable period if (1) the moisture content of the seed can be kept as low as possible, (2) the temperature in the vicinity of the seed can be kept as low as from 0° to 5°C., or (3) the seed is kept in oxygen-free atmosphere.

When circumstances permit, there is much to be said for equipment to dry the grass seeds carefully to well below 10 per cent moisture content, and for the construction of special store-houses to regulate atmospheric temperature when valuable seed stocks are concerned. Even when there is no necessity to store the seed beyond one year, the super-drying of grass seeds results in more vigorous growth; if the seed is to be held over for several seasons the need for drying is still greater. Of two stocks, which must be stored for a year or more, that which shows the highest germination figures will keep more satisfactorily. Seeds with rather indifferent germination test figures deteriorate at an alarming rate when stored under ordinary conditions.

Two pests in particular are apt to interfere with stored grass seeds, (1) moth grubs, and (2) mice, not to mention rats. There is evidence that moth grubs can be controlled by dusting the seeds with the more lethal type of mercuric powder marketed under proprietary names for treating seeds; the so-called non-poisonous types of mercuric compounds are not so effective. There is some evidence that rodents find seeds treated with mercuric powders less attractive. When quantities larger than the standard two ounces of mercuric compound per bushel of grass seed are applied, the excess powder can be retrieved at the time of sowing or sale by passing the seed over appropriate screens.

E. SUCCESSIVE SEED CROPS.

Strains bred for their capacity for high tillering and persistency naturally retain their vigour longer when cultivated for seed than the ordinary hay strains of commerce. It is not surprising therefore to find vigorous stands of a leafy cocksfoot (S.26) and a leafy timothy (S.51) after seven successive crops of seed. Thorough cultivation, manuring and good management are essential to maintain seed productivity for a number of years.

Factors other than longevity of a strain as such may govern the length of time during which it can be usefully maintained to produce seed. Fungous diseases and insect pests are more liable to appear when a stand is cropped continuously for seed over a long period. When the seed area lies in a situation favourable to the appearance of fungous diseases and insect pests, it is vitally important for the seed grower to make a close study of each seed crop before harvesting his crops every year. This precaution will enable the grower to determine whether there are signs of a pest which may spread from a slight attack in one year to an attack disastrous to a seed crop in the following year.

An incipient attack of *Epichloe* on a grass seed crop should warn the grower that there is a possibility of a more severe attack in the following year; grasses which have been growing for several years are subject to severe attacks of midges (*Contarinia* and *Dasyneria* spp.), hence the necessity of taking appropriate measures to safeguard crops from such infestations. Once they have taken a firm hold of a seed area, it is advisable to plough up the crop. The timothy fly (*Amaurrosoma* spp.) is another pest which reduces the seed yield in certain districts in some years, although in seed areas in England and Wales the damage is not great; the pest is not necessarily cumulative in a stand, as is usually the case with several other pests.*

Broadcast stands of a persistent type of perennial ryegrass with wild white clover are in a class of their own. On suitable land four options are presented to the grower after the first ryegrass seed crop has been harvested, namely, to grow (1) a further ryegrass seed crop next year, (2) a wild white clover seed crop, (3) a hay crop, or (4) graze the sward; a similar choice can be made in later years. The persistent perennial ryegrass—wild white clover sward, is thus very elastic and is well suited to the economy of a mixed farm, for even when ryegrass seed crops are taken it is possible to graze the sward until March; if a white clover seed crop is to be taken, grazing to the middle of June is necessary. With skilful management, the ryegrass and the wild white clover can be made to dominate in alternate years, one advantage of this scheme being that it tends to suppress insect pests specific to these crops.

Broadcast stands of red fescue tend to become sod-bound after the two crops of seed, and respond to vigorous harrowing. Perhaps a more effective method is to plough narrow, steep furrows shortly after the last seed crop has been harvested. Young growth soon appears between these furrows to betoken a vigorous seed crop in the following year. Broadcast areas which have become much contaminated by coarse grasses are hardly worth regenerating, and should be replaced by other crops.

*See also Aberystwyth, Imperial Bureau of Plant Genetics: Herbage Plants. Bull. No. 20. Insects and other pests injurious to the production of seed in herbage and forage crops. By H. F. Barnes, Aberystwyth, 1937. pp. 31.

F. CROPS TO FOLLOW GRASS SEED CROPS.

Broadcast crops of ryegrass associated with wild white clover can be ploughed easily and produce excellent cereal crops by virtue of the fertility accumulated in the soil by the clover. There is even a danger of the cereal crops lodging if the ploughed sward had been dominated by white clover for a year or two, hence the need for choosing such crops as stiff-strawed cereals or potatoes.

Areas which have grown successive grass seed crops for a number of years in drills cannot be expected to produce as heavy cereal crops as areas where a clover root has been ploughed in, unless the ground is heavily manured. The succeeding crop should then preferably be either a root or a leguminous one.

The first problem facing the seed grower is the destruction of the plants in the abandoned drills. This is a comparatively easy matter for timothy, ryegrass and fine leaved fescue, as the top growth is not usually very bulky after the last seed crop has been removed; a cocksfoot stubble is a little more difficult to manage. Wherever and whenever possible, such stubbles should be burnt during July or August, taking the usual precaution against firing the fences, when it is an easy matter to plough the land immediately after. Where it is deemed advisable to make use of the organic matter in the aftermath, rather than have it burnt, and it must be admitted that burning is only possible during hot summers, the drills are grazed as severely as possible before ploughing.

The ploughing must be shallow or deep. By ploughing a shallow furrow under the drill, only a little soil remains attached to the grass clods; these can, with the use of the cultivator, roller and harrow, be made virtually soil-free and can be collected and burned in heaps. Ploughing across the drills helps the cleaning process better than ploughing in the direction of the drills.

Another plan is to graze the stubble hard and to use two ploughs following each other, the one to make a deep furrow between the drills, and the other a shallower furrow under the grass stubble, which is thrown and buried in the deeper furrow. Two things are essential in this connexion; the first is to bury the stubble completely and the second to hasten its rotting. Such stubble is a valuable source of organic matter, but if it does not decompose, poorer crops might follow than if it were absent. With ample nitrogen supplied in one form or another, not only to feed such crops, but to assist the decomposition of the buried stubble, this disability is removed. One obvious method of doing this is to apply short farmyard manure to the stubble before it is ploughed in early autumn. New growers do not always realize that, as far as the nutrition for a succeeding crop is concerned, the ploughed stubble of grass drills has not the immediate manurial value of a ploughed red clover root, or a sward rich in white clover, owing to the lack of available nitrogen. Although a good supply of this element may be locked up in the ploughed stubble, it will be released only for later crops, unless measures are taken to hasten its decomposition.

5. PRODUCTION OF SEED FOR GENERAL DISTRIBUTION.

Supplies of stock seeds of pedigree grass strains from the third multiplication stage become available for distribution to organizations for bulk multiplication to supply the farmers' needs.

During the past few years, multiplication of pedigree grass seed has been undertaken by the leading seed houses in Great Britain, and by Seed Growers' Associations. The first Seed Growers' Associations in Great Britain were formed to grow and market authenticated supplies of regional varieties of red clover seeds. A Seed Growers' Association has been established for each local variety, each with its own rules, regulations and method of marketing, but the one essential feature of these organizations is the inspection of crops and the certification of all true stocks offered for sale. Among the chief associations operating for this purpose are the Montgomery Late Flowering Red Clover Seed Growers' Association, Ltd., Cornish Marl Red Clover Seed Growers' Association, Essex Seed Growers' Association, and Vale of Clwyd Red Clover Seed Growers' Association. Later, some of these already established organizations undertook to multiply and certify seed stocks of the Station's grass and clover strains, and new Associations such as the Hereford Seed Growers' Association and the Hay-Talgarth Seed Growers' Association, and the South-Western Grass Seed Growers' Association were established solely for the purpose of growing and marketing strains produced at the Welsh Plant Breeding Station.

At the present time, negotiations are in progress with a view to setting up a central organization to deal with the whole question of large-scale growing and distribution of the strains of the Welsh Plant Breeding Station. In the organization contemplated, collaboration will be assured between the Station on the one hand and the Seed Trade and the Growers' Associations on the other, while a complete scheme of inspection and certification will be incorporated.

6. BRED STRAINS RELEASED BY THE WELSH PLANT BREEDING STATION.

GRASSES.

PERENNIAL RYEGRASS (*Lolium perenne*).

Early hay strain S.24. Originated from plants found in various situations, but none of the foundation plants are directly derived from commercial seed. Expected to be somewhat more persistent than ordinary commercial and more leafy, yielding a less stemmy hay and aftermath.

Late hay strain S.101. Originated from truly indigenous plants. Is now being increased. Late-flowering and therefore should be in much better condition at the usual hay-making time. Type, relatively broad-leaved, erect and very leafy, but tillering less densely than the pasture strain S.23. Should be much more persistent than the ordinary commercial. For most practical purposes, for use in seeds mixtures when a hay crop is desired in the first and second harvest years, it is expected that a mixture of S.23 and S.101 would give the best results.

Pasture strain S.23. Typically late-flowering, relatively prostrate habit, producing very dense, grassy plants under good conditions. Essentially a persistent pasture type, particularly on good soils. Bred from plants derived from excellent old pastures.

TIMOTHY (*Phleum pratense*).

Hay strain S.51. Hay type, leaves rather broad and long and plants well leaved up. Tillers fairly numerous. Colour somewhat lighter green than ordinary commercial timothy, and plants much more rust-resistant. Rather late-flowering.

Pasture strain S.48. A pasture type of the ordinary tall, broad-leaved timothy. Good, dense, grazing type, leaves not very long. Habit, on the average, not very erect. Has been found to be very persistent under heavy grazing.

Extreme pasture strain S.50. Somewhat variable in habit, but typically rather prostrate and very spreading. Very dense and grassy, producing long non-flowering shoots late in the season. These shoots run close to the ground and become rooted at the nodes when trampled and pressed into the soil; thus the plants persist by vegetative propagation.

COCKSFOOT (*Dactylis glomerata*).

Pasture-hay strain S.26. This population was built up from the original caging of five typical and very large tussock plants collected from a gorse brake in Devonshire. It is not therefore an absolutely pure breeding stock—pure to any one definite growth form. This line, however, has been more extensively tested than any other produced at the Station, and has given rise to bulky and leafy plants of marked persistency which have shown to excellent advantage on soils hardly good enough for perennial rye-grass. A further interesting feature of this strain has been the very good and persistent stands that it has given at relatively high elevations. It is more essentially a pasture type, but gives good crops of leafy hay. This was at first distributed fairly widely for experimental purposes under its breeding number, namely, Bc. 1163.

Hay strain S.37. This strain has been built up by bringing together the progenies from a number of selfed plants representing leafy, erect hay types. Some of the original plants were derived from selections taken from New Zealand plants, and others were indigenous. This strain starts growth earlier in the spring than S.26, or than the definitely pasture strains, but gives a decidedly more leafy hay than Danish, than which it is not much later. Probably not as persistent as the later and more prostrate pasture types.

Pasture strain S.143. This has been built up on the same lines as S.37. The original plants were, however, very prostrate, multi-tillered and rather broad-leaved. This, it is believed, represents the most promising of all the definite pasture strains and in the preliminary trials is making very dense and attractive swards.

MEADOW FESCUE (*Festuca pratensis*).

Pasture-hay strain S.53. A population worked up from indigenous leafy plants—suitable for pasture and hay. It gives a good crop of rather late hay and a rapid growing, dense aftermath.

RED FESCUE (*F. rubra*).

S.59. Moderately widely and not very densely creeping; very winter-green; leaves long and relatively soft. Not intended to take up all the ground, but to fill up between other species. Is showing to good advantage in swards at comparatively high elevations. Although not explicitly bred for the purpose, shows considerable promise as a lawn grass.

SHEEP'S FESCUE (F. ovina).

S.58. Originated from seed of indigenous plants. Relatively very dense, very leafy for this species, dark green. It is thought that this strain may prove valuable in connection with the improvement of poor and waste grazings.

CLOVERS.

RED CLOVER (Trifolium pratense).

S.123. A late flowering strain built up of some forty families of Montgomery and Cornish Marl. It produces heavy yields of hay in the second year and is more persistent than the parent varieties—yielding good crops in the third and fourth years.

S.151. An early leafy strain of broad red clover, three to five days later than English broad red. Yields heavier hay crops in the first year than ordinary broad red. Persists better than English broad red in the second year. Tillers more freely than the latter, and is for use for one or two-year hay-producing leys.

WHITE CLOVER (T. repens).

S.100. A large-leaved, early strain produced from New Zealand, Australian, and large-leaved indigenous forms. It is very suitable for one to three-year leys as it is far more productive than the ordinary white clover variety generally used for short leys.

